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Orientation selection in lamellar phases by oscillatory shears

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Recent interest in block copolymers arises from their ability to self assemble at the nanoscale through microphase separation and ordering, leading to mesophases with various types of symmetries, such as lamellar, cylindrical, or spherical. A macroscopic sample manifests itself as a polycrystalline configuration consisting of locally ordered but randomly oriented domains (or grains), with the presence of large amount of topological defects and unusual rheological properties. The development of the equilibrium state characterized by macroscopic orientational order, as desired in most of applications, requires unrealistically long times; hence external forces, such as steady or oscillatory shears are usually applied to accelerate domain coarsening and induce long range order.

We discuss here possible mechanisms for orientation selection of lamellar phases under imposed oscillatory shears based on a mesoscopic model of the low frequency rheology of the copolymer. The reversible or reactive contribution to the local stress is standard and follows from local lamellar curvature. We also introduce a constitutive law for the dissipative part which is consistent with the uniaxial symmetry of the phase. This assumption leads to a dependence of the effective dynamic viscosity on orientation of the lamellar phase. Given this model, we study the motion of various grain boundary configurations separating stable domains of different orientations relative to the shear. Although the bulk domains considered are stable, the grain boundary is not. Hence, grain boundary motion is seen to act as a possible mechanism for orientation selection in block copolymers.

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